[illegible] TRANSMISSION [illegible]

[illegible]

[illegible] Method

w_T = Width of film in inches

l_T = Length of film in inches

With N black lines/mm in each direction

Number of Lines in l_T direction = $N l_T \times 25.4$

Number of Lines in w_T direction = $N w_T \times 25.4$

t = Time in seconds for one scan line = $N l_T \cdot 25.4 / f_m$

f_m = highest frequency transmitted = [illegible] bandwidth

T_f = Time to transmit one frame = $N^2 \cdot 25.4^2$

ϕ = Factor greater 1 to indicate excess of scan lines to transmit N lines

So T_f

$$T_f = \frac{N w_T \cdot 25.4 \cdot N l_T \cdot 25.4 \phi}{f_m}$$

ϕ is a number between 2 & 3 and comes about because the detail is positioned arbitrarily with respect to the scan lines

3 [illegible]

$$T_f = \frac{(25.4)^2 \times 3 \; N^2 \; W_T \cdot l_T}{4}$$

$$T_f = \frac{1935 \; N^2 \; W_T \cdot l_T}{\Delta f} \quad (1)$$

or

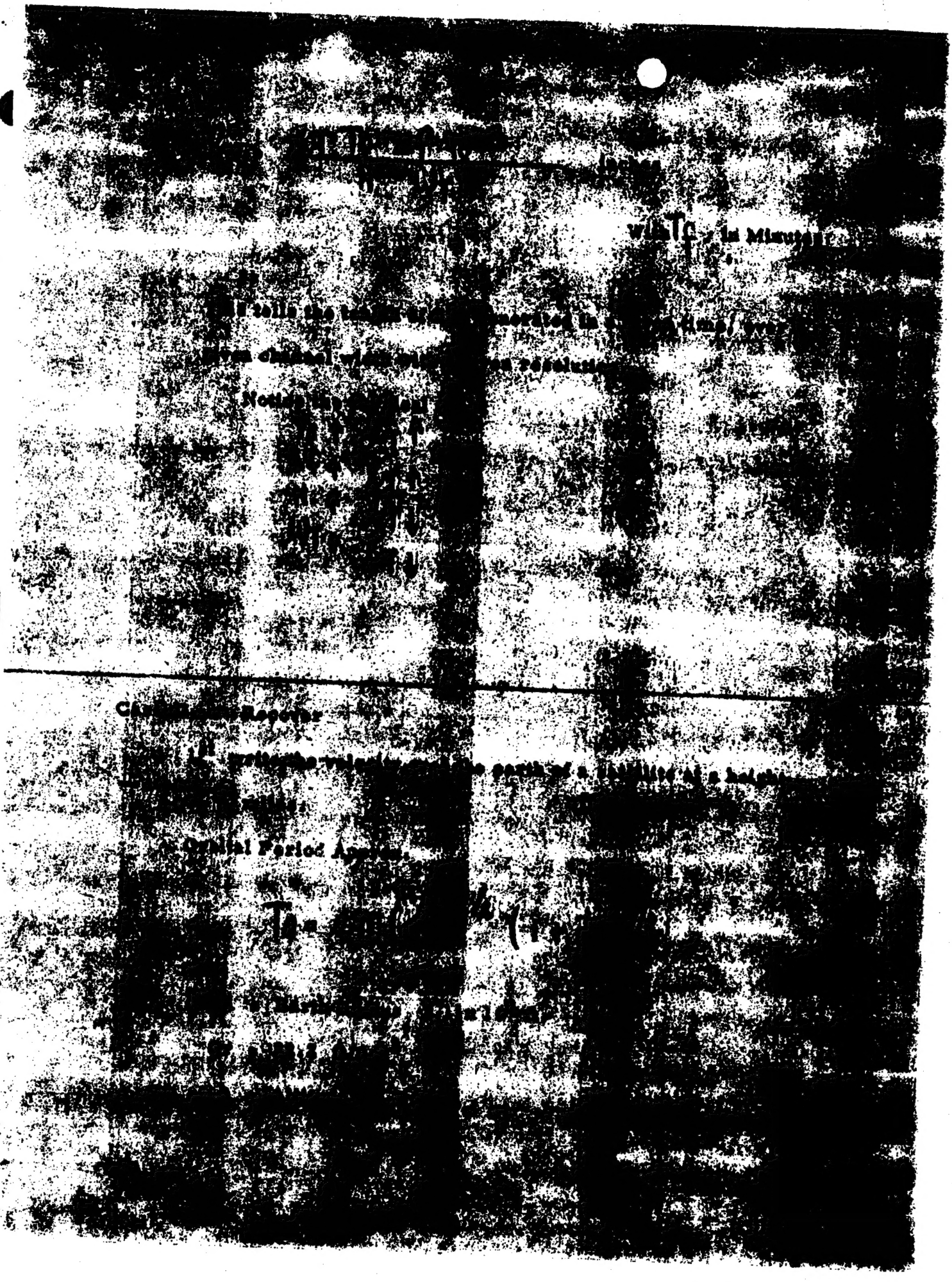
$$l_T = \frac{T_f \cdot \Delta f}{1935 \; N^2 \; W_T} \quad \text{inches} \quad (2)$$

T_f = Frame time in seconds

Δf = in cycles/seconds

W_T = in inches

N = lines/mm



V_e = Velocity over the earth

$$V_e = \sqrt{\frac{2GM}{r}} = \sqrt{\frac{2 \times 32.2 \times 3960}{r}} = \left(\frac{254{,}000}{r}\right)^{1/2}$$

For h in Miles

$$V_e = 25{,}400 \left(1 + \frac{h}{4000}\right)^{-1/2} \text{ ft/sec}$$

Now the velocity of a point on the [illegible]

$$V_1 = \frac{V_e f}{h} \text{ ft/sec}$$

f = focal length in Miles

$$V_1 = \frac{V_e f}{12 \times 6000\, h} \text{ ft/sec}$$

f in inches

$$V_2 = \frac{V_e f}{6000\, h} \text{ in/sec} = \frac{V_e f}{100\, h} \text{ in/Mile}$$

l_f = length of recovered film = $\frac{f T_e}{100\, h}$ inches

c

$$K = \frac{2.42 \times 10^{-2} \left[1 + \frac{h}{4000}\right]^{3/2} f T_f}{h}$$

h in Miles

f in Inches

T_f in Min.

Inches

Ratio $\frac{K}{L_T}$ when ≥ 1 Received Noise

when < 1 Transmitted Noise

$$a = \frac{2.42 \times 10^{-2} f T_f 10^{8} N^2 W_T}{\left[1 + \frac{h}{4000}\right]^{3/2} h \; 5.1 \; T_f \; \Delta f} \; Q^{4.5}$$

where Q indicates losses in reproducing the transmitted image.

(A number between 2 & 5)

$$G = \frac{8450 f N^2 W_T Q^2}{h \Delta f \left[1 + \frac{h}{4000}\right]^{3/2}}$$

f in Inches

N in Lines/Inch

W_T in Inches

h in Miles

Δf in cycles/sec

$\Delta f = 6 \times 10^6$ $\quad \lambda = 200$

$$\frac{\quad \times 10^{-} \quad \times 10^{2}}{200 \times 6 \times 10^{6}}$$

$$= \frac{1.96 \times 4}{10 \times 1076} W_T Q^2 = 2.28 W_T Q^2$$

Conservatively $Q = 2$

$Q = 2$ is more conservative (that is favors [illegible] more) than Buchheim P 222 Space Handbook.

$$G = 9.4 W_T$$

Recovered systems very conservatively receive [illegible] the info

must be stressed that recovered systems are the only ones ... cover geometry. There is no comparison. Scanning systems ... linearity are unsuited for long measurement problems. The ... is limited to resolution and information content.

... last point - recovered film resolution is limited by lens, ... processing etc. but not scanning and transmission and reproduction ... degradation. These effects are all taken into Q,

Q to be between 2 to 5

So the gains given are the smallest, smallest, possible.

Now consider the time a transmitter is in sight of a receiver with ... reasonable signal to noise ratio. For approximately 90 min. orbit, 15 passes/day, transmitter in contact 4 min/pass

(At least 3 stations to get this average amount)

Reasonable transmission time in 24 hours is 64 min.

If you recover at 24 hrs. satellite it will have seen 16 ... daylight.

Gain of approx. 10.

Apply this to Gain fig. on page 6, we get gains for the various film widths of 260 to 850 times.

When recovering 5" Film

gains as high as 400 are reasonable

When recovery 9" Film

gains as high as 850 are reasonable.

It is generally said that recovery and [illegible] about [illegible] to realize. This is the BMD position, for example. We feel recovery is easier and since it gives much more information and [illegible] recovered records, we feel it should be specified for all systems where the information perishes in a few hours. Even then it is not clear that this highly perishable information can be detected by [illegible] If it can, then consideration should also be given to "once over" vehicles since this is maximum information in [illegible] time.

[redacted] RECOVERY

The E-2 system, operating at its maximum capacity every day for its entire 90 day lifetime and subject to no lost or [redacted] film and no [redacted] jamming will give an area coverage of about 3.56 million square miles over the Sino-Soviet area. At the scale of about 1/450,000 as presently considered, this is equivalent to less than 30 pounds of thin base film.

The coverage is not limited by the data gathering ability of the camera but rather by the readout time required by the [redacted] system and the total lifetime of the vehicle. If a recovery system is considered, the same camera can obtain the same coverage in only 10 days, or conversely could obtain 9 times the amount of coverage in the same 90 days. Also, if alternate cameras are considered, the data gathering time could be further shortened or the scale enhanced or both.

The amount of film which could be safely [redacted] in a recovery system would be roughly 30 times the 30 pound equivalent now in the vehicle.

Thus, both total coverage and scale could be easily improved with a recovery system, to say nothing of the [redacted] of a shorter lifetime satellite.

Comparison Table

	Telemetry	Recovery
Area Coverage	42,900 square miles/day	380,000 Square Miles/
Linear Coverage	2520 statute Miles/day	22,400 Statute Miles/day
Time of Operation	90 days	10 days
Frame/day (.8 x 17 Sat)	3150	28,000
Total Coverage	3.86×10^6 Square Miles	3.86×10^6 Square Miles
Film Weight	30 pounds	330 pounds

Recovery can carry greater film weight than 30 pounds, therefore, for completeness

Film Weight	110 pounds
Coverage	Total of 10 million [illegible]
Time	35 Days

The latter part of the comparison table shows that with only 110 pounds of film, a recoverable satellite could [illegible] complete coverage of the Soviet Union and China.

Thus, consideration of telemetry systems for return of photographic data from space vehicles leads one to [illegible] that even a [illegible] channel is not sufficient to [illegible] as it can be [illegible]

Using very wide band data links to [illegible]

transmitter power ing[illegible] the problem
of Doppler correction becomes [illegible] very [illegible] tra[illegible]
link, the relative frequency shift [illegible] components [illegible] and of
the sideband spectrum will be [illegible] shifted [illegible] the other end.
This would have the effect of degrading the quality of intelligence being
transmitted. Suitable corrections would have to be made, either at the
sending end, or at the receiving end if quality is to be restored. The problem
then centers about the ability of the receiving terminal to determine the
relative velocity of the vehicle, [illegible] rate of change in velocity
due to the different locating angles [illegible] for adding or
subtracting frequency shifts proportional to the Doppler shift.

Other approaches to increasing the communication rate without increasing the bandwidth have been proposed. Methods such as velocity modulation, dot arresting, level slicing and digitizing have all been proposed but none of them has ever proven practical.

The other problems which are normally considered in the communications business such as phase distortion, [illegible] should also enter into any comparison discussion. All of the above, along with the restrictions [illegible], will have a [illegible] effect on the final data and must be considered.